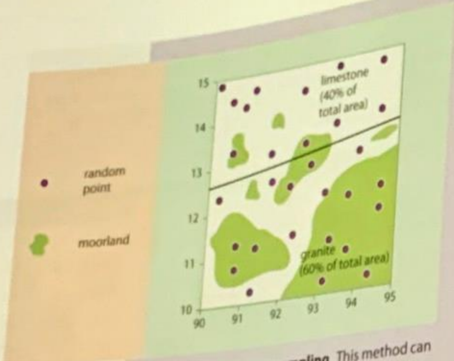



Figure 6.41
A random point sample, stratified by area

**2 Stratified random sampling** This method can be used to cover a wide range of data, both in interviewing and in geographical fieldwork and map work. For example, Figure 6.41 shows the distribution of moorland on two contrasting rock types: granite occupies 60% of the total area and limestone 40%. To discover whether the proportion of moorland cover varies with rock type, the sampling must be in proportion to their relative extents. Thus, if a sample size of 30 points is derived using random numbers, 18 are needed within the granite area (18 is 60 per cent of 30) and 12 within the limestone area (12 is 40 per cent of 30). If it was decided to area sample, 18 quadrats would have to fall within the granite area, and 12 in the limestone.

The advantages of stratified sampling include its potential to be used either randomly or systematically, and in conjunction with point, line or area techniques. This makes it very flexible and useful, as many populations have geographical sub-groups. Care must be taken, however, to select appropriate strata.

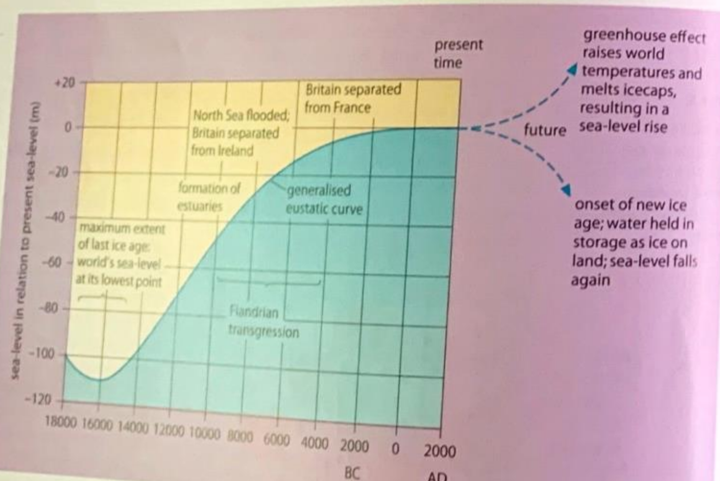
## Changes in sea-level

Although the daily movement of the tide alters the level at which waves break onto the foreshore, the average position of sea-level in relation to the land has remained relatively constant for nearly 6000 years (Figure 6.42). Before that time there had been several major changes in this mean level, the most dramatic being a result of the Quaternary ice age and of plate movements.

During times of maximum glaciation, large volumes of water were stored on the land as ice – probably three times more than today. This modification of the **hydrological cycle** meant that there was a worldwide, or **eustatic** (glacio-eustatic, page 123), fall in sea-level of an estimated 100–150 m.

As ice accumulated, its weight began to depress those parts of the crust lying beneath it. This caused a local, or **isostatic** (glacio-isostatic, page 123), change in sea-level.

Figure 6.42
Eustatic changes in sea-level since 18 000 BC






The world's sea-level was at its minimum 18 000 years ago when the ice was at its maximum (Figure 6.42). Later, as temperatures began to rise and icecaps melted, there was first a eustatic rise in sea-level followed by a slower isostatic uplift which is still operative in parts of the world today. This sequence of sea-level changes may be summarised as follows:

1 Formation of glaciers and ice sheets. Eustatic fall in sea-level gives rise to a negative change in base level (page 81).
2 Continued growth of ice sheets. Isostatic depression of the land under the ice produces a positive change in base level.
3 Ice sheets begin to melt. Eustatic rise in sea-level with a positive change in base level.
4 Continued decline of ice sheets and glaciers. Isostatic uplift of the land under former ice sheets results in a negative change in base level.

During this deglaciation, there may have been a continuing, albeit small, eustatic rise in sea-level but this has been less rapid than the isostatic uplift so that base level appears to be falling. Measurements suggest that parts of north-west Scotland are still rising by 4 mm a year and some northern areas of the Gulf of Bothnia (Scandinavia) by 20 mm a year (Places 23, page 166). The uplift in northern Britain is causing the British Isles to tilt and the land in south-east England to be depressed. This process is of utmost importance to the future natural development and human management of British coasts (Figure 6.56).

Tectonic changes have resulted in:

- the uplift (**orogeny**) of new mountain ranges, especially at destructive and collision plate margins (pages 17 and 19)
- local tilting (**epeirogeny**) of the land, as in south-east England, which has increased the flood risk, and in parts of the Mediterranean, leading to the submergence of several ancient ports and leaving others stranded above the present-day sea-level
- local volcanic and earthquake activity, as in Iceland.

## Landforms created by sea-level changes

Changes in sea-level have affected:

- the shape of coastlines and the formation of new features by increased erosion or deposition
- the balance between erosion and deposition by rivers (page 81) resulting in the drowning of lower sections of valleys or in the rejuvenation of rivers, and
- the migration of plants, animals and people.

### *Landforms resulting from submergence*

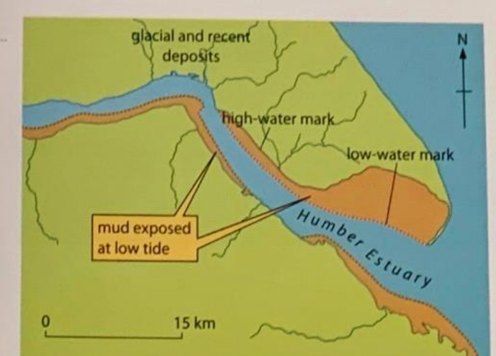
Eustatic rises in sea-level following the decay of the ice sheets led to the drowning of many low-lying coastal areas.

**Estuaries** are the tidal mouths of rivers, most of which have inherited the shape of the former river valley (Figure 6.45). In many cases, estuaries have resulted from the lower parts of the valleys being drowned by the post-glacial rise of sea-level. Being tidal, estuaries are subject to the ebbs and flows of the tide, and usually large expanses of mud are revealed at low tide (Figure 6.43). Many estuaries widen towards the sea and narrow to a meandering section inland (Figure 6.44).

Estuaries are affected by processes that are very different from those at work along rivers and coasts, because of particular features.

- **Residual currents** are created by the mixing of fresh water (from rivers) and saline water (sea water brought in by the tides). Mixing tends to take place only when discharge and velocities are high; otherwise the fresh river water, being less dense, tends to rise and flow over the saline water.
- **Tidal currents** have a two-way flow associated with the incoming (flood) and outgoing (ebb) tide.
- Continuous variations in both **discharge** and **velocity** resulting from the tidal cycle. Tidal velocities are highest at mid-tide and reduce to zero around high and low water. Times of zero velocity result in the deposition of fine-grained sediments, especially in upper estuary channels, which form mudflats and saltmarsh.

Figure 6.43
The Humber estuary



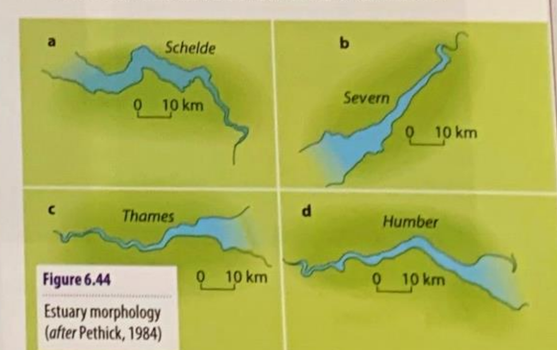




Figure 6.44
Estuary morphology (*after* Pethick, 1984)